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A.D. 1828 . . . . . N° 5659.

SPECIFICATION

OF

SAMUEL HALL.

APPARATUS FOR GENERATING STEAM, GASES, &c.

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Apparatus for Generating Steam, Gases, &c.

HALL'S SPECIFICATION.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, SAMUEL HALL, of Basford, in the County of Nottingham, Cotton Manufacturer, send greeting.

WHEREAS His present most Excellent Majesty King George the Fourth, by His Letters Patent under the Great Seal of Great Britain, bearing date at Westminster, the Thirty-first day of May, in the ninth year of His reign, did, for Himself, His heirs and successors, give and grant unto me, the said Samuel Hall, His especial licence that I, the said Samuel Hall, my executors, administrators, and assigns, or such others as I, the said Samuel Hall, my executors, administrators, and assigns, should at any time agree with, and no others, from time to time, and at all times during the term of years therein expressed, should and lawfully might make, use, exercise, and vend, within England, Wales, and the Town of Berwick upon Tweed, and also within all His said Majesty's Colonies and Plantations abroad, my Invention of "**A METHOD OF AND AN APPARATUS FOR GENERATING STEAM AND VARIOUS GASSES TO PRODUCE MOTIVE POWER, AND FOR OTHER USEFUL PURPOSES**;" in which said Letters Patent there is contained a proviso, obliging me, the said Samuel Hall, by an instrument in writing under my hand and seal, particularly to describe and ascertain the nature of my said Invention, and in what manner the same is to be performed, and to cause the same to be inrolled in His said Majesty's High Court of Chancery within six calendar months next and immediately after the date of the said recited Letters Patent, as in and by the same, reference being thereunto had, will more fully and at large appear.

NOW KNOW YE, that in compliance with the said proviso, I, the said Samuel Hall, do hereby declare that the nature of my said Invention, and the manner in which the same is to be performed, is described and ascertained as follows, that is to say:—

The nature of my said Invention consists in the combustion of coal, wood, or other suitable materials in an artificial atmosphere greatly superior in density, pressure, and elasticity to the natural atmosphere surrounding the earth, for the purpose of generating steam and various gasses to produce motive power, and for other useful purposes, by which means fuel is economized. I will, firstly, explain my method of putting it in practice, and then describe my apparatus for that purpose.

My method of generating steam and various gasses is by creating within a part of the apparatus an artificial atmosphere, of much greater elasticity and density than the atmosphere surrounding the earth, in which artificial atmosphere, which should be of at least double the density of the common atmosphere, the combustion of fuel is made to take place for the purposes mentioned in my Patent.

The fire so subjected to the action of the artificial atmosphere is to be surrounded by water, contained in an arrangement of cylindrical channels which I call water tubes; they are cast or formed in the sides of the cylinder or vessel containing such fire, and a portion of the steam generated by the fire is to be caused to pass through such fire to carry away the heat as it is generated, and prevent its becoming so intense as rapidly to destroy such cylinder or vessel, or produce the great quantity of scoria or slagg, which is formed by steam engine fires in general. The gasses thus generated by the combustion of the fuel are, as well as the steam which is also generated thereby, to be applied in the following manner to produce motive power:—The steam and gasses in their condensed state are to be made to act upon a piston working within a cylinder, and they are to be allowed to escape into the atmosphere after having acted upon the piston in the manner practised with high pressure steam engines.

And now, in further compliance with the said proviso, I, the said Samuel Hall, shall proceed to explain the manner in which my said Invention is to be performed by the following description thereof, reference being had to the Drawings annexed, and to the figures and letters marked thereon; but before so doing, I shall give a general description of the vessels which form the principal parts of my apparatus; namely, one which I call the atmospheric cylinder; another, which I call the generator; another, which I call the reservoir; and another, which I call the working cylinder. (There may be any number of generators, according to the power of the engine, but it is only

necessary to describe one, as they are all alike, but there ought never to be fewer than two generators.) There is a piston to work in the atmospheric cylinder, as well as another to work in the working cylinder. The general description I am about to give will be best understood by reperusing it, after having carefully examined the Drawings and the explanations thereof. The atmospheric cylinder is of a proportionably less internal capacity than the working cylinder, according to circumstances, videlicet, the power of the engine and the degree of pressure of the artificial atmosphere. The engine described by this Specification has an atmospheric cylinder, whose internal diameter is fifteen inches and a half, the piston making a sixteen-inch stroke; and a working cylinder, sixteen inches internal diameter, with the piston making a twenty-four inch stroke. The atmospheric cylinder is furnished with a bottom and cover, to each of which is attached a branch pipe. In the cover are fixed two valves, and two similar ones are fixed in the bottom; one of those in the cover opens inwards, and admits the atmospheric air into the cylinder; the other opens outwards into the pipe attached to the cover, through which the air is expelled and forced through other pipes into the generator, (which is a cylindrical vessel with a fire-place in the centre, and two sets of cylindrical channels surrounding it; one set to contain water, and another set for the passage of the gasses from the fire in commixture with steam;) and precisely the same operation takes place with the valves fixed in the bottom of the cylinder. The two branches attached to the cover and bottom are united together by flanches, and connect with the other pipes to convey the air to the generator, and pass it through the fire contained therein, and then through a system of cylindrical channels, which, for the sake of distinction, I call gas tubes, similar to the water tubes already mentioned, between which they are arranged intermediately and alternately, and, like them, surround the fire, being cast or found in the sides of the generator. When the various gasses and steam have passed through the whole of this system of gas tubes, they are conveyed by pipes leading to and connecting with the reservoir, which is a cylindrical vessel with a hemispherical bottom, and with a cover fixed to the top, and from thence by other pipes to the working cylinder, which is similar to the cylinder of a high-pressure steam engine, to act alternately upon and underneath the piston contained therein, in a similar manner to the action of steam upon the piston of a common high-pressure steam engine. The generator and reservoir, as well as the pipes which connect the four vessels together, contain the artificial atmosphere of which I have spoken, which may be produced of any density and elasticity which the strength of the materials forming those vessels and pipes is capable of bearing with perfect safety. The supply of steam and gasses to the working cylinder

must be so regulated as not to allow the artificial atmosphere to be lowered. This is to be done by cutting off such supply at a proper point of the stroke of the piston by any of the usual methods practised by engineers, so that the gasses and steam may act by expanding during the remainder of its stroke, and any superabundant steam may be allowed to escape by a valve into the atmosphere. In order to illustrate the mode of first producing and then maintaining an artificial atmosphere of any required density and elasticity within the generator and reservoir and connecting pipes, I must suppose those parts of the apparatus to be filled with air of the density of the atmosphere, and that by forcing air into them by an air-pump, or by any other suitable means, the internal pressure is brought up to the required point, which, for example, we will suppose to be one hundred and fifty pounds on the square inch, and we will suppose that air of the atmosphere condensed into a tenth part of its volume is of a density equal to one hundred and fifty pounds upon the square inch. Now, supposing the atmospheric cylinder to be ten times the internal capacity of the working cylinder, and that the two pistons are put in motion by some extraneous power, every stroke of the atmospheric piston will cause the air contained in the cylinder in which it works to pass into the generator and reservoir and connecting pipes, where it is compressed into one-tenth part of its original volume. When, therefore, it has passed through those vessels and pipes, the same quantity escapes by the working cylinder at each stroke that is introduced by the atmospheric cylinder at each stroke; therefore the intermediate artificial atmosphere within the generator and reservoir and pipes will always be kept up to its pressure of one hundred and fifty pounds upon the square inch; or in case the working cylinder be of the same internal capacity as the atmospheric cylinder, the supply of air to the working cylinder from the generator and reservoir must be cut off by a valve or otherwise when the piston has made one-tenth part of its stroke, so that the atmospheric air compressed into one-tenth part of its bulk, which is so introduced into the working cylinder at each stroke of the piston, is allowed to expand during the remaining nine-tenths of the stroke thereof to its original volume. This calculation, which is merely for the purpose of illustration, is made upon the supposition that no loss takes place from the imperfections of pistons and other parts of machinery, nor from the heat produced and lost by condensation; but as both of these effects will, of necessity, take place, an allowance in practice must be made for them. It may be proper to mention here, that if in the above mode of illustration the working cylinder were of greater internal capacity than one-tenth of that of the atmospheric cylinder, and the supply of air were not cut off, the equilibrium between the natural and artificial atmospheres would soon be restored, by the latter being

reduced to the same density as the former. It is evident, then, that the capacity of the working cylinder must be of a proper relative proportion to that of the atmospheric cylinder. I use an atmospheric cylinder and a working cylinder of the dimensions already mentioned, with one hundred and fifty pounds pressure upon the square inch. It is obvious, that in the above illustration, where no fire is applied nor steam produced, the relative sizes of the atmospheric cylinder and working cylinder pointed out must be proper; but when heat is applied and steam produced to pass along with the heated gasses into the working cylinder, the relative proportions of the capacities of the two vessels must be very different, as above stated.

Having given the general description or summary account of the principal parts of my apparatus, as mentioned in an early part of this Specification, I now proceed to give a particular description and detailed account of the more minute parts of my apparatus by referring to the annexed Drawings. In order to do this, I shall, firstly, describe all the parts of the atmospheric cylinder; secondly, all the parts of the generator; thirdly, all the parts of the reservoir; fourthly, all the parts of the working cylinder, and then proceed to shew how they are all connected together, and in what manner they act to produce the effects I have described; similar letters and numerals being used to denote similar parts of the apparatus in all the Figures, whether in the plan, the elevation, or the section thereof, some parts of the apparatus being shewn in one Figure only, and some in another, while others are shewn in several Figures.

Firstly, the atmospheric cylinder A, Figures 1 and 2, is composed of a cylinder H, with flanches at the top and bottom, to which are attached by screw bolts a cover I and a bottom J, the latter having four ears or projections *g*, *g*, *g*, *g*, to support the whole vessel by four pillars L, L, &c. placed underneath. One of the pipes Z, Z, branches from the cover, and the other from the bottom of the atmospheric cylinder; both of which are united by flanches to pipes P, P, &c., which lead to and connect with the bottom of the generator, as will be hereafter explained. In the cover of the atmospheric cylinder are fixed two valves *a*, *b*, and two similar ones are fixed in the bottom; the valves *a* opening inwards, to admit the atmospheric air into the cylinder, and the valves *b* opening outwards, to allow the air to pass from it into the pipes Z, Z, from them to the pipes P. P, &c., connected therewith, and leading to the bottom of the generator; *c* is a piston, with a piston rod *d*, which works through a stuffing box on the cylinder cover, and is connected with one end of the working beam G, *a*, by the working of which it is put in motion; and at the other end of the beam is attached a rod connecting it with a fly wheel fixed on a shaft, for communi-

cating the power of the engine in the usual manner. The atmospheric cylinder is firmly fixed to the bottom of the iron framework X, X, &c., being attached thereto by bolts passing through the supporting pillars aforesaid.

Secondly, the generator B, Figures 1, 3, 4, and 5, is constructed of three principal parts; one I call the main cylinder G, another the bottom cylinder I, *a*, and the third the cover J, *a*, all being attached together by flanches and screw bolts, so as to form one entire air-tight vessel. In the centre of the main cylinder, which I shall first describe, is a cylindrical space of about fourteen inches diameter, to contain the fuel for combustion under an artificial atmosphere. In the sides of the main cylinder of the generator, from the top to the bottom, are cast or formed the system of water tubes *k*, *k*, *k*, *k*, &c., already mentioned. They are connected together at the top by the circular or curved grooves *l*, *l*, *l*, *l*, &c., and are also connected together precisely in the same manner as the bottom of the cylinder, by similar grooves. All the water tubes are two inches in diameter. On the generator cover, exactly over and connecting with one of the water tubes, is fixed a stop cock W, which is attached to a pipe X, to convey away part of the steam from the water tubes to the bottom cylinder of the generator. This steam passes of course, through this fire along with the air from the atmospheric cylinder on its way to the gas tubes. There is another similar stop cock *y*, fixed over and connecting with another water tube attached to the short pipe Z, which is to convey into the curved pipe *a*, *a*, on the top thereof, such part of the steam as is required to pass above or beyond the fire, and proceed along with the gaseous matters arising from the fire into and through the gass tubes, and from them to the working cylinder, passing in their course thereto through the reservoir, as will be hereafter more fully explained. The grooves connecting the tubes both at the top and bottom are one inch wide and three inches deep; by these grooves the water in the tubes is freely connected at the bottom, and the steam at the top, so that the height of the water is the same in all the tubes. There is also another system or arrangement of intermediate and alternate tubes *m*, *m*, *m*, *m*, &c., similar to the others, which for the sake of distinction I call gas tubes. They are also two inches in diameter, except the two marked with an *, each of which latter is two inches and three-quarters diameter. These gas tubes are all connected together, being united at the top by grooves *n*, *n*, *n*, *n*, &c., and at the bottom by grooves *o*, *o*, *o*, *o*, shewn by dotted lines. These grooves both at the top and bottom of the tubes are of the same width and depth as those connecting the water tubes. Over one of the large tubes *m** is cast or formed in the cover a curved pipe or tube *a*, *a*, which forms a connection to that tube from the interior of the generator containing the fire,

whereby the air and steam which pass through such fire, or the various heated gasses formed thereby, as well as the steam that enters above the fire, are conveyed to the gass tubes and passed through them, first entering by the said large tube m^*, with comes in connection with the curved tube *a*, *a*, in the cover, and having passed down to the bottom of that tube, branch off right and left by the two adjoining grooves, shewn by dotted lines marked *o*, *o*, then rising up the two nearest gas tubes to the top, they branch off in a similar manner right and left by the next two adjoining grooves, shewn by the plain lines and marked *n*, *n*, and thus proceed, descending and ascending by the remaining gas tubes and connecting grooves till they arrive at the other large gas tube m^*, from the upper part of which branch pipe *p*, which leads by the pipes attached to it, to be shewn hereafter, first to the reservoir, and then to the working cylinder. It is plain, therefore, that the heated gaseous matters from the fire by passing through all the gas tubes, and of course between all the water tubes, till they escape by the said branch pipe *p*, must impart heat to the water within the water tubes. The four ears or projections *r*, *r*, *r*, *r*, are attached to and form a part of the bottom flanch of the main cylinder of the generator, by which it is supported on pillows K, K, K, K, which are fixed upon a plate of iron *s*, *s*, *s*, *s*. This being fixed on masonry work, and the pillars being hollow, a bar of iron is passed through each of them, and by means of a screw and nutt at the top of each bar, and a bolt or wedge at the bottom, or by any other suitable means, the foundation plate, the pillars, and the main cylinder of the generator are all firmly fixed together; the bottom cylinder thereof can then be attached to and detached from the main cylinder at pleasure, without at all disturbing the latter. The fire within the generator is supported on a grate or plate of iron *t*, perforated with small holes, which may be raised or lowered by a rod *u* (to which it is attached) working through a stuffing box fixed underneath and in the center of the bottom cylinder, being cast to it and forming a part thereof. To the lower end of this rod a bar or lever V is attached, to raise or lower it when the apparatus is at work, and the fire is, of course, within the generator; the grate ought to be raised so high as that the fuel may be within the main cylinder and above the bottom flanch thereof; the ashes, &c. that fall down through the grate may be removed by taking the door or cover Y, Y, off the aperture upon which it is firmly placed by a screw pressing upon it, which is fixed on the cross bar Z ×, the ends of which are held by being firmly bolted to two iron studs attached to the side of the bottom cylinder. There is also a third stud similarly attached, from which the door Y, Y, is suspended by an iron bar, which moves upwards and downwards upon a pin or axle. This door may be fixed

on the aperture by any other convenient means. By lowering the grate at the bottom of the generator, the fire as well as the ashes may be withdrawn at the said aperture; but before opening the door or cover for that purpose, the artificial atmosphere must be reduced to the pressure of the common atmosphere, by shutting valves T, *a*, and T, *b*, and stop cocks W & Y, and then opening the stop cock *a*, *b*, in the bottom cylinder of the generator. In one of the water tubes is a float, shewn by dotted lines, to ascertain the height of the water in that tube, and, of course, in all the other water tubes, in order that they may be kept properly supplied. The float must be suspended by a wire *b*, *b*, which passes through the cover of the generator, the small passage hole being made as steam-tight as possible by the round ball or weight through which the wire passes, for between it and the generator cover a little thread is wrapped round the wire, which being pressed down by the weight of the ball, makes the wire work as through a stuffing box. This wire must be connected to a chain *d*, *d*, which is attached to one end of the lever *w*, *l*, and at the other end thereof must be suspended by another similar chain the weight or counterbalance *e*, *e*, the whole being supported by the pillar N. Besides the float, I have affixed to the apparatus a glass water guage, attached to the top and bottom of one of the water tubes in the usual manner, to ascertain the precise height of the water within the tubes. The cover of the generator has in the centre, and forming a part thereof, a short pipe or branch O with a flanch on the top, on which is fixed a kind of box L, which forms part of an apparatus for supplying the fire from time to time with fuel. This I call the slide box, it having a slide to move backwards and forwards therein, which will be described hereafter. This slide box is closed by a cover *c*, *a*, having a pipe M, forming a part of and branching from it upwards, which I call the feed pipe; it rises up exactly over the pipe O on the generator cover, forming therewith a vertical passage for the introduction of the fire and fuel. Within the slide box is the slide *b*, before mentioned, which, when moved so as to be underneath the feed pipe, separates it from the generator, and this pipe is closed at the top by a cover *c*, *f*, the four ears or projections thereof being firmly pressed upon by four screws $l\times$, $l\times$, $l\times$, $l\times$, fixed in the four bars $\times m$, $\times m$, &c., which are attached to the sides of the feed pipe. The slide may be moved backwards and forwards by a rod *d*, *r*, fixed to it, and working through a stuffing box attached to the slide box; this rod is connected to a screw *g*, *s*, which is provided with a handle *s*, *h*, by which the slide is moved at pleasure to shut or open the lower end of the feed pipe. Underneath the slide are two springs, one of which is shewn by letter *j*, fastened internally to the bottom of the slide box, pressing up the slide

to make it bear up in close contact with the cover *c*, *a*, of the slide box L, and to close the lower extremity of the feed pipe. The fuel intended to be introduced into the generator is first put into a cylindrical vessel ×*f*, which I call the fuel box, shewn both within the feed pipe and detached from it; it has a moveable bottom *f*, *b*, of a conical or other convenient form, for the fuel to slide off if when it is lowered from the box. The conical bottom is fixed on the end of a rod ×*h*, which is kept in a vertical position by two internal stays ×*i*, *i*, attached to the insides of the box. The apparatus for supplying fuel is provided with a small pipe ×*j*, and a stop cock *k*, *a*, to connect the slide box occasionally with the feed pipe, as will be hereafter explained.

The manner of supplying the generator with fuel when the apparatus is at work is as follows:—The bottom of the feed pipe being closed by slide *b*, the cover being taken off, and the fuel box being removed, I fill the fuel box with fuel, which is kept within it by the moveable conical bottom being kept within the bottom of the box; I then put it so filled into the feed pipe, and put on the cover, the rod ×*h* passing through the stuffing box thereon; when the cover is tightly screwed down, the fuel occupies a space above the fire-place, and detached therefrom by slide *b*, which is now required to be withdrawn, but as the high pressure of the gasses and the steam acting on the under side of the slide makes it difficult to be removed, I open the stop cock *k*, *a*, to allow the gasses and steam to pass into the feed pipe, whereby the pressure becomes the same above the slide as below it. The equilibrium of the pressure above and below the slide being thus effected, the slide is easily removed from underneath the feed pipe by turning the handle *s*, *h*; that being done, the fuel box and its contents are to be lowered by means of the rod ×*h* till they rest upon a ring ×*n*, ×*n*, which is fixed to and underneath the cover J, *a*, of the generator; this prevents their further descent; but by pressing down the rod ×*h*, the conical bottom is lowered from the fuel box, so as to let the fuel descend from it into the fire within the generator. The conical bottom is then to be drawn up till it comes again into the fuel box, which it must then bring along with it into the feed pipe, the bottom of which is then to be closed, by the slide being passed underneath it. The cock *k*, *a*, must now be closed, to cut off the communication between the generator and the feed pipe, and the cover may then be removed to allow the fuel box to be taken out to receive a fresh supply of fuel. ×*o* is a safety valve fixed on the generator cover over and connecting with one of the water tubes; it is fixed on a spindle ×*p*, and can be turned round by the handle fixed upon it, so as to bring the valve into accurate contact with its seat. The lever ×*q* is fixed on the spindle with two collars, and is held steady by the pillar ×*r*, in the top whereof is a slit through which the

lever passes, and there is a screw that enters the top of the pillar to regulate the height to which the lever should be lifted when the steam becomes of too high pressure. Some of the peculiarities and excellences of the generator deserve pointing out. Common boilers, especially those of high-pressure steam engines, although at first they be sufficiently strong to be perfectly safe, and even may be so after having been a considerable time subjected to and worn by the heat of an intense fire, will in process of time become so weak as to burst, and from the impossibility of ascertaining the precise time when that becomes the case, many serious accidents and explosions take place; but from the construction and application of this generator it is not so liable to those evil consequences, for the exterior thereof is not exposed to the action of the fire, and the interior is protected therefrom, not only by the water, steam, and gasses contained in the surrounding tubes, but also by the portion of steam which is passed through the fuel, and which prevents such accumulation of heat taking place as would rapidly destroy the materials of which the generator, as well as the grate supporting the fire, is formed. The abundant formation of scoria or slagg, which is produced from most kinds of coal by steam engine fires in general, is also by this means prevented. It is worthy, too, of remark, that one important peculiarity in this generator consists in the circumstance, that when the external part thereof is sufficiently strong there is no danger of explosion, when at work, arising from its destruction by fire, even if the interior part thereof, which is alone exposed to the action of the fire, were to give way, as there is the same pressure, or nearly so, within the fire-place outwards as there is within the tubes containing the water, steam, and gasses inwards, therefore the result of the giving way of the interior side would merely be the passing of water, steam, and gasses from the tubes into the fire and extinguishing the same.

I now proceed, thirdly, to describe the reservoir shewn by the letter C, Figures 1, 3, 4, 5. It is a plain cylinder or retort, with a hemispherical bottom, and closed with a cover *a*, *r*. There are two pipes branch from it, one at the lower extremity *b*×, and the other near the top *c*×; on the cover are fixed a safety valve and an apparatus for suspending a float within the reservoir to ascertain the height of the water therein. They are precisely the same as those belonging to the water tubes of the generator, except that the float and its counterbalance are heavier and larger; it is therefore unnecessary to mark the parts with letters or repeat the description thereof. The branch pipe *b*×, at the bottom of the reservoir, is to allow the gasses and steam from the generator to enter and pass through it in their way to the working cylinder, as well as to admit a supply of water from a force pump to the reservoir, and to

allow the water to be drawn therefrom by a stop cock attached thereto, as occasion may require; and the other branch $c\times$, near the top, is to allow the gasses and steam to proceed on their passage from the reservoir to the working cylinder. The reservoir is to be set on masonry work, forming an external fire-place under it and flues around it in the usual ways, to heat the water therein and generate steam for the purpose of creating the artificial atmosphere within the apparatus, in the first instance, and for starting the engine. When that is done the fire underneath the reservoir may be withdrawn. The fire-place and ash-hole doors (for there must be a door to each, and a damper, which must be fixed in the chimney) ought then to be closed in order to prevent any draught of cold air from passing through the fire-place or flues; within the water in the reservoir are placed three shelves or plates of iron at about six inches distance from each other, perforated with a great number of small holes and supported by an iron pillar passing through the centre of them, with bolts or wedges put into the pillar to keep them suspended at the above mentioned distance from each other; these are to cause the gasses to be washed and purified after the modes used for purifying gas for illumination, and a portion of lime or other suitable material may be introduced into the water, if found necessary, according to the nature of the fuel employed.

Fourthly, I shall now explain the parts of the working cylinder marked D, Figures 1 & 2. It is similar to a common high-pressure steam engine cylinder, being closed at the bottom and furnished with a cover to the top, provided with a stuffing box for the piston rod to work through, which is attached to the working beam G, *a*, being kept while working in a vertical position by the usual apparatus for producing a parallel motion. The various gasses act upon a piston working within this cylinder in conjunction with steam, and they are both allowed to escape into the atmosphere after having acted upon the piston. The cylinder in question has a passage 1, 1, in the side thereof, to admit the gasses and steam to act underneath the piston during its assent, and to allow them during its descent to escape into the atmosphere by passing thereto through the middle aperture 3 and pipe 4 through vessel Y, which is surrounded by the water, in which the force pump Q is placed, for the opening 6 into that vessel is connected to pipe 4 by a pipe, not shewn in any of the Drawings. 2, 2, is a similar passage, to allow the gasses and steam to enter into the upper part of the cylinder, to act above the piston during its descent, and to escape in a similar manner into the atmosphere during its assent; *f*, *f*, is a box into which the gasses and steam are admitted on their passage to the working cylinder through the passages 1, 1, and 2, 2; 5 is a slide valve, to slide over passages 1, 1, and 2, 2, to admit the gasses and steam from the box *f*, *f*,

to pass alternately in at the bottom and top of the working cylinder and out again into the atmosphere. When this slide connects the box *f*, *f*, with the lower part of the working cylinder by passage 1, 1, it connects the upper part thereof with the atmosphere by uniting the passages 2, 2, and 3 together, leading, as already explained, by pipe 4 through vessel Y. When the piston has arrived at the top of the cylinder the slide reverses the entrance and exit of the gasses and steam by connecting the box *f*, *f*, with the upper part of the working cylinder by passage 2, 2, and the lower part with the atmosphere by the union of passages 1, 1, and 3, and the pipe 4 and the vessel Y.

Having now described the four principal parts of my apparatus, I shall proceed to shew how they are all connected together. Firstly, the connection of the atmospheric cylinder with the generator; secondly, the connection of the generator with the reservoir, and thirdly, the connection of the reservoir with the working cylinder.

Firstly, the pipes P, P, &c., Figures 1, 2, and 3, being attached to the atmospheric cylinder by means of the branches Z, Z, connect it with the bottom cylinder I *a* of the generator; secondly, the gas tubes of the generator are connected from its branch pipe *p* with the lower branch pipe P× of the reservoir by pipes R, R, R, Figure 1 and 3; and thirdly, the upper branch pipe *c*× of the reservoir is connected with the working cylinder by pipe S, Figure 3. Some of the useful purposes to which the steam and various gasses generated by my method and apparatus may be applied, are the heating of liquids for bleaching, dyeing, and various other purposes, as well as for warming rooms, factories, &c.; for if the steam and gasses are generated in greater abundance than is required for the working of the engine, a part of them may be conveyed from pipe S, by pipes branching therefrom, for all the various useful purposes for which they may be required, just upon the same principle that the boilers of common steam engines, when sufficiently large, supply steam, not only for working the engine, but for heating fluids, and for many other useful purposes, or a part of the steam may be conveyed away for similar purposes from the upper ends of the water tubes before they enter the gas tubes and become mixed with the gasses.

I must now point out several valves and boxes which are fixed in different parts of the apparatus, for connecting or cutting off the communication between the different parts thereof; they are, like the valve T, shewn in section, Figure 4, having two flanches *a*, *f*, and *b*, *f*, the valve itself being marked *c*, *v*; there is one of these boxes T, *a*, Figure 1 and 3, containing a valve attached by flanch *b*, *f*, to pipes P, P, &c., and by flanch *a*, *f*, to short pipe P×, attached to and connected with the bottom cylinder of the generator. This is

to cut off the connection of the atmospheric cylinder with the bottom of the generator, when requisite; there is a second similar valve box T, *b*, (with its valve,) attached by flanch *a*, *f*, to pipe *p* of the generator, and by flanch *b*, *f*, to pipes R, R, R, to cut off the connection of the generator with the reservoir, when requisite; there is a third valve box T, *c*, (with its valve attached by the flanch *a*, *f*, to branch pipe *c* × of the reservoir, and by flanch *b*, *f*, to pipe S. This is to cut off all communication between the working cylinder and reservoir; by this valve the engine may of course be put in motion and stopped at pleasure. There is a fourth valve box T, *a*, Figure 2, with its valve attached by its flanch *a*, *f*, to the steam box *f*, *f*, and by flanch *b*, *f*, to pipe S, by means of a curved pipe of a proper shape, not shewn in any of the Drawings, which unites them together. This valve is to admit and cut off at any part of the stroke of the piston the supply of steam and gasses to the working cylinder, as already explained; besides these, there are two other valve boxes like E, Figure 4; one of these, E, *a*, Figure 3, is fixed in and connects together the pipes P, P, &c. This valve is to allow the air to pass from the atmospheric cylinder to the generator, but to prevent its returning and passing in a contrary direction, the other valve box E, *b*, Figure 3, is fixed in and connects together the pipes R, R, R, and is intended to allow the steam and gasses to pass from the generator to the reservoir, but to prevent them from passing in a contrary direction. In addition to the apparatus already described, there is a force pump Q, Fig. 2, already mentioned, which is surrounded by water, to supply the reservoir and the water tubes of the generator with water, the plunger or piston whereof is worked by beam G, *a*, to which beam is also attached the rod of the piston within the working cylinder, as already mentioned. There is a range of small pipes U, U, U, Figs. 1 & 3, to convey the water from the force pump as above stated, to the water tubes of the generator and to the reservoir. There are two stop cocks *t* 1 & *s* 1, the former to admit the supply of water to the reservoir, and the latter to do the same to the water tubes aforesaid; and there is a third stop cock shewn, *s* 2, to convey water to the water tubes of a second generator. The force pump can be detached from the working beam, and be worked with a lever, by manual labour, to fill the reservoir and water tubes of the generator to the proper height, preparatory to setting the engine to work. There are two other stop cocks, *s* 3, and *s* 4, Figs. 1 and 2; to the latter is attached a pipe *z*, *b*, leading to and connecting with pipe *z*, *z*, which enters the curved tube *a*, *a*, on the top of the generator. These cocks and pipes are for the occasional introduction of water into the gas tubes *k*, *k*, *k*, &c., to wash and clean them; for by opening cock *s* 4, and shutting cock *s* 3, the force pump is

connected with the gas tubes, while it is shut off from the water tubes and from the reservoir. There is another range of small pipes F, F, F, Fig. 3, with two stop cocks V 1 & V 2; these are to connect the reservoir with the water tubes of the generator to heat the water, and get the steam therein up to the proper pressure previously to setting the engine to work; when that is effected the cocks V 1 & V 2 may be closed. In order to set the engine in motion, the reservoir and water tubes must be filled with water to the proper height indicated by the floats; the water tubes must be disconnected from the gas tubes and internal part of the generator by closing cocks W and Y; the valve T, *a*, being opened, fires must be made underneath the reservoir and within the generator. The door Y, Y, on the bottom cylinder being opened, the slide *b*, within the slide box L, being withdrawn, and the cover of feed pipe *c*, *f*, being taken off, the density of the steam within the reservoir and water tubes must be brought up to the required point, videlicet, about one-tenth part greater density than that at which the engine is required to work, as it will be somewhat lowered in getting to work. The density of the steam is to be regulated by putting proper weights on the levers of the safety valves on the reservoir and generator; this being the case, and the steam being brought up to the required density, the door Y, Y, on the bottom cylinder of the generator and the bottom of feed pipe M, must be closed by the means already mentioned, after which the valve T, *c*, must be opened to admit the gases and steam into the working cylinder to act upon the piston therein. This puts the working beam G, *a*, and of course the piston of the atmospheric cylinder, which is attached thereto, in motion, as well as the plunger or piston of the force pump. As soon as the whole is thus in motion, and the pressure of the air within the apparatus is brought up to the required density, which is ascertained by the valve fixed on pipes P, P, &c., the valve T, *b*, must be opened to allow the condensed air to pass from the atmospheric cylinder to the generator, and the gasses and any undecompcsed air to pass from thence to the reservoir, and from thence to the working cylinder along with the steam. The cocks W and Y, which are both of the same size, must then be opened, to allow the steam to pass above and below the fuel, as already described. The fuel box must be supplied with fuel, which must be introduced, as already described, into the generator upon grate *t* by the feeding apparatus, and the supply repeated as it is consumed, and as the fire requires replenishing. The best mode I am acquainted with of uniting together the different parts of the apparatus is, either by grinding the surfaces or flanches required to be united, or by inserting between them a collar of lead well painted, and screwing them tightly together by screw bolts. It will be advantageous to surround the generators and pipes,

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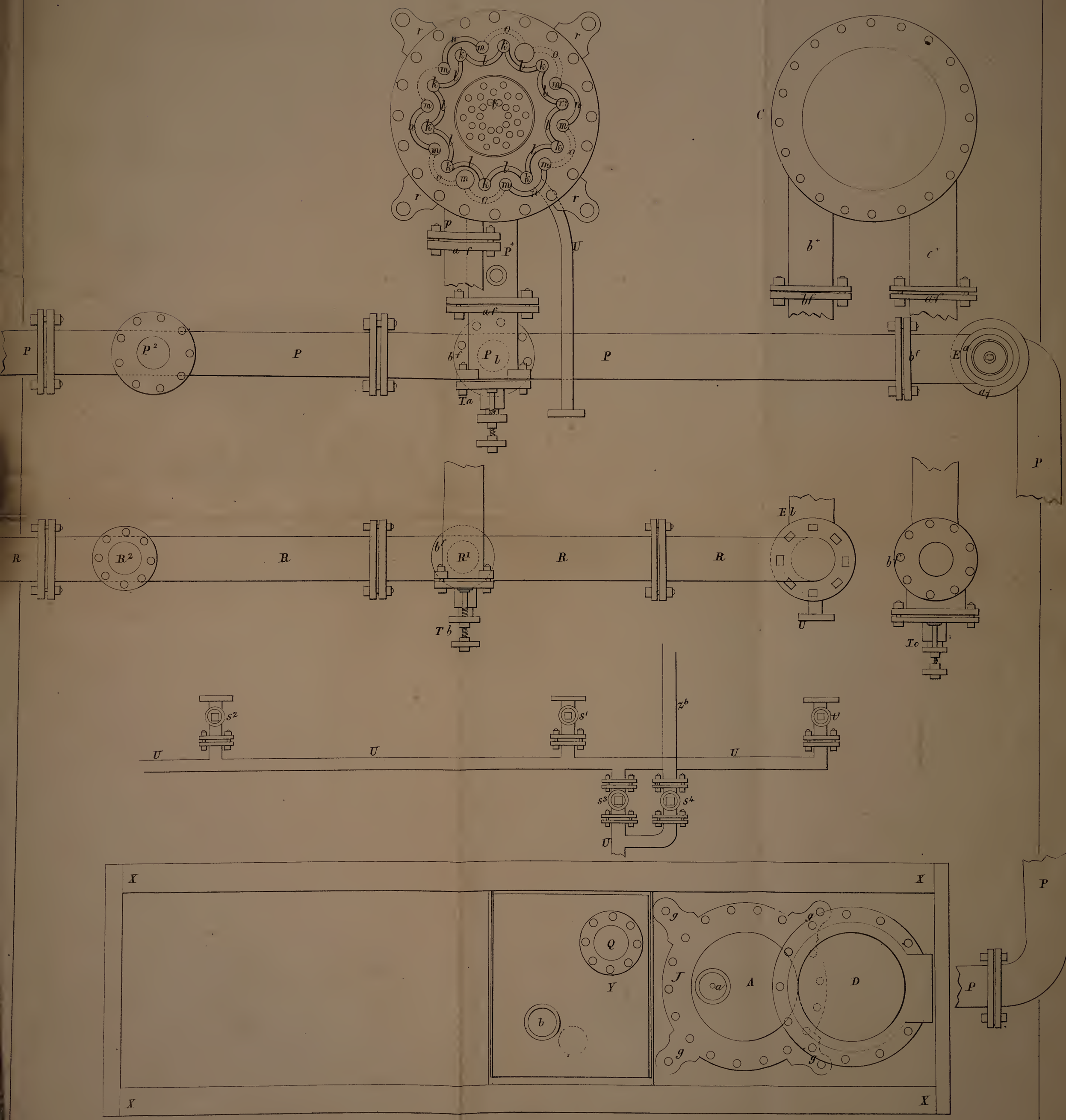
HALL'S Specification.

Fig. 1.

Plan of the Apparatus.

Scale one inch to the foot.



The Enrolled drawing is colored.

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(5 SHEETS.)

FIG. 2.

Elevation in Section of the
Atmospheric & Working Cylinders &c.
Scale one inch to the foot.

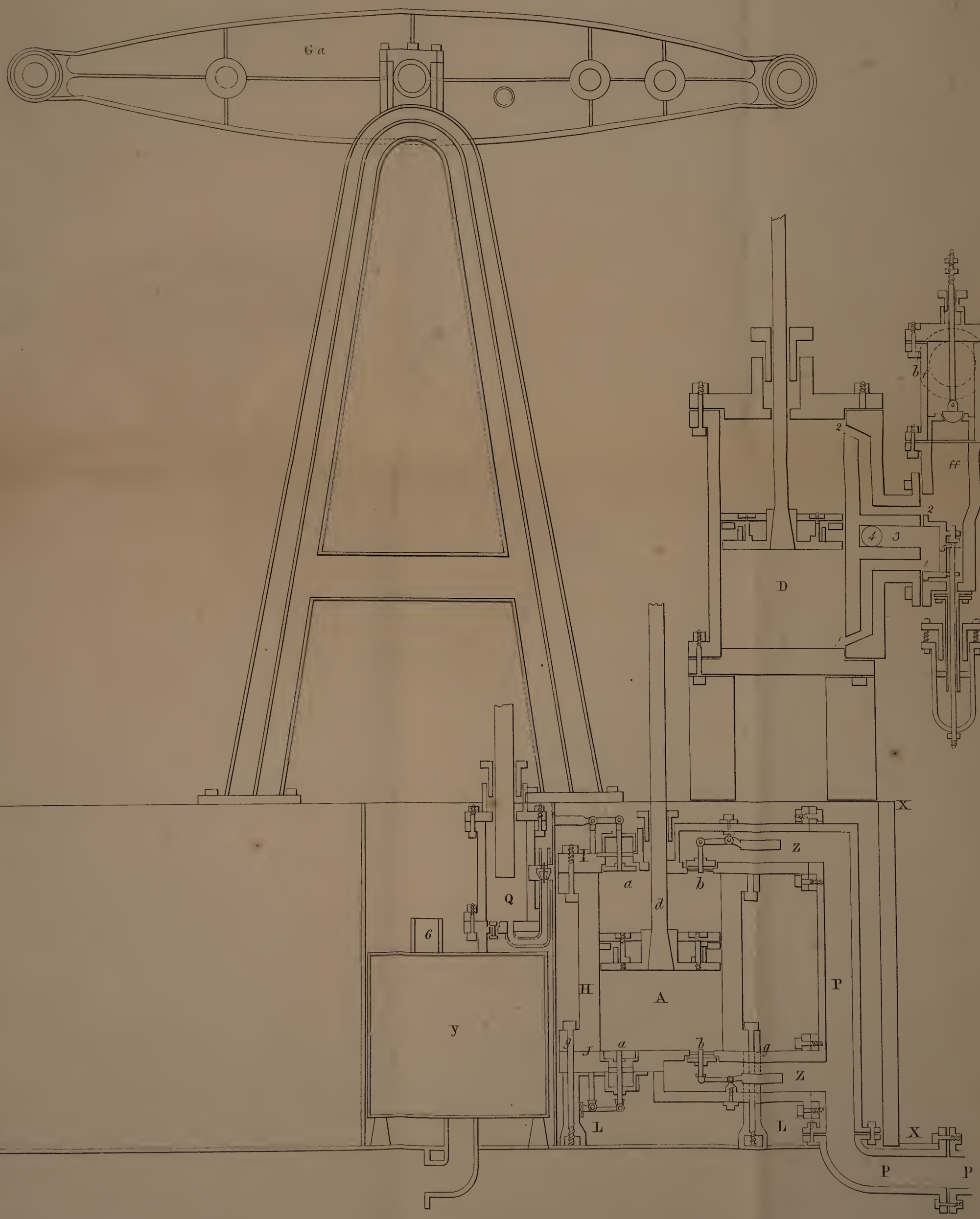

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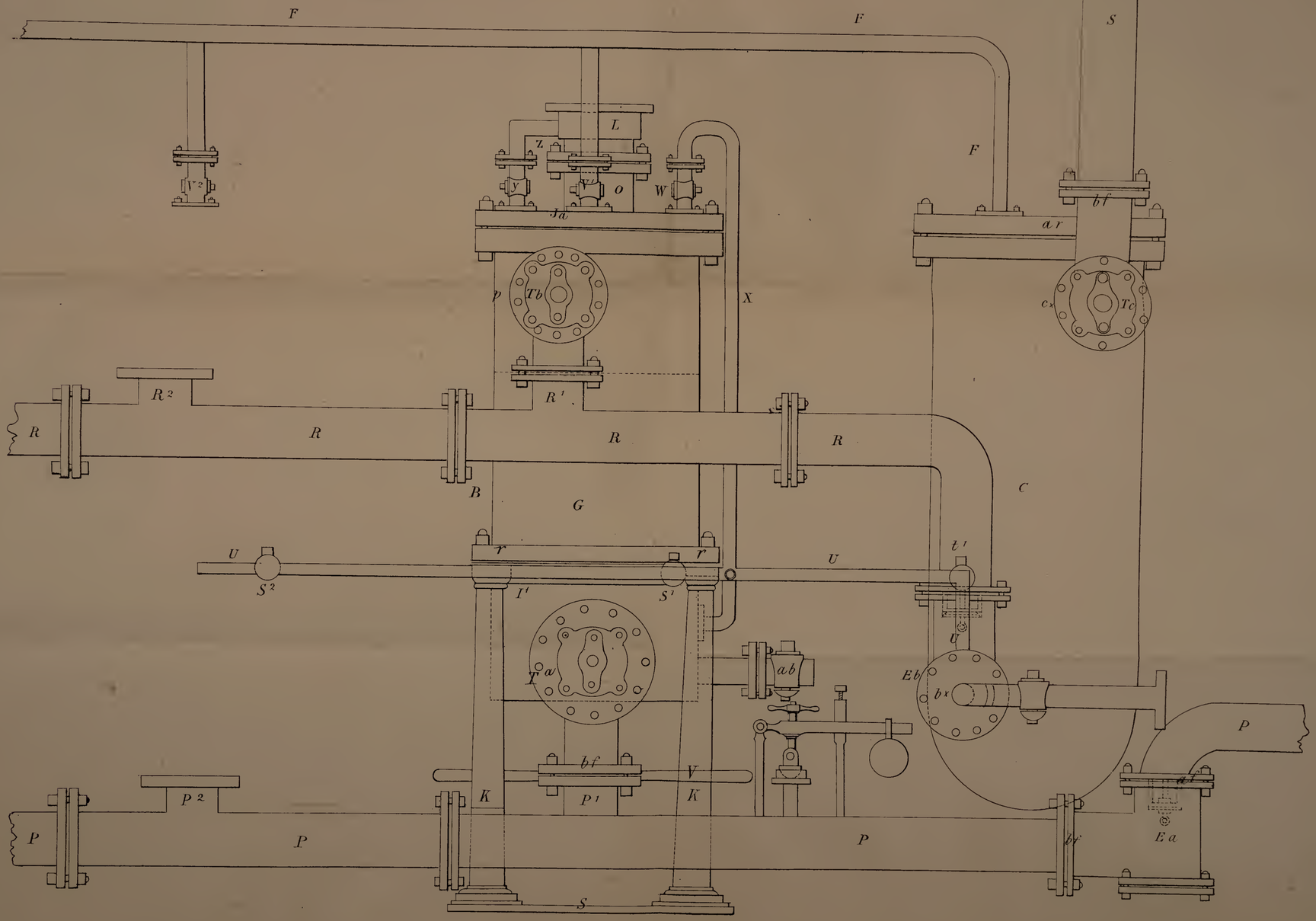
FIG. 3.

Elevation of the front of the Generator and Reservoir &c.

Scale, One Inch to the Foot.



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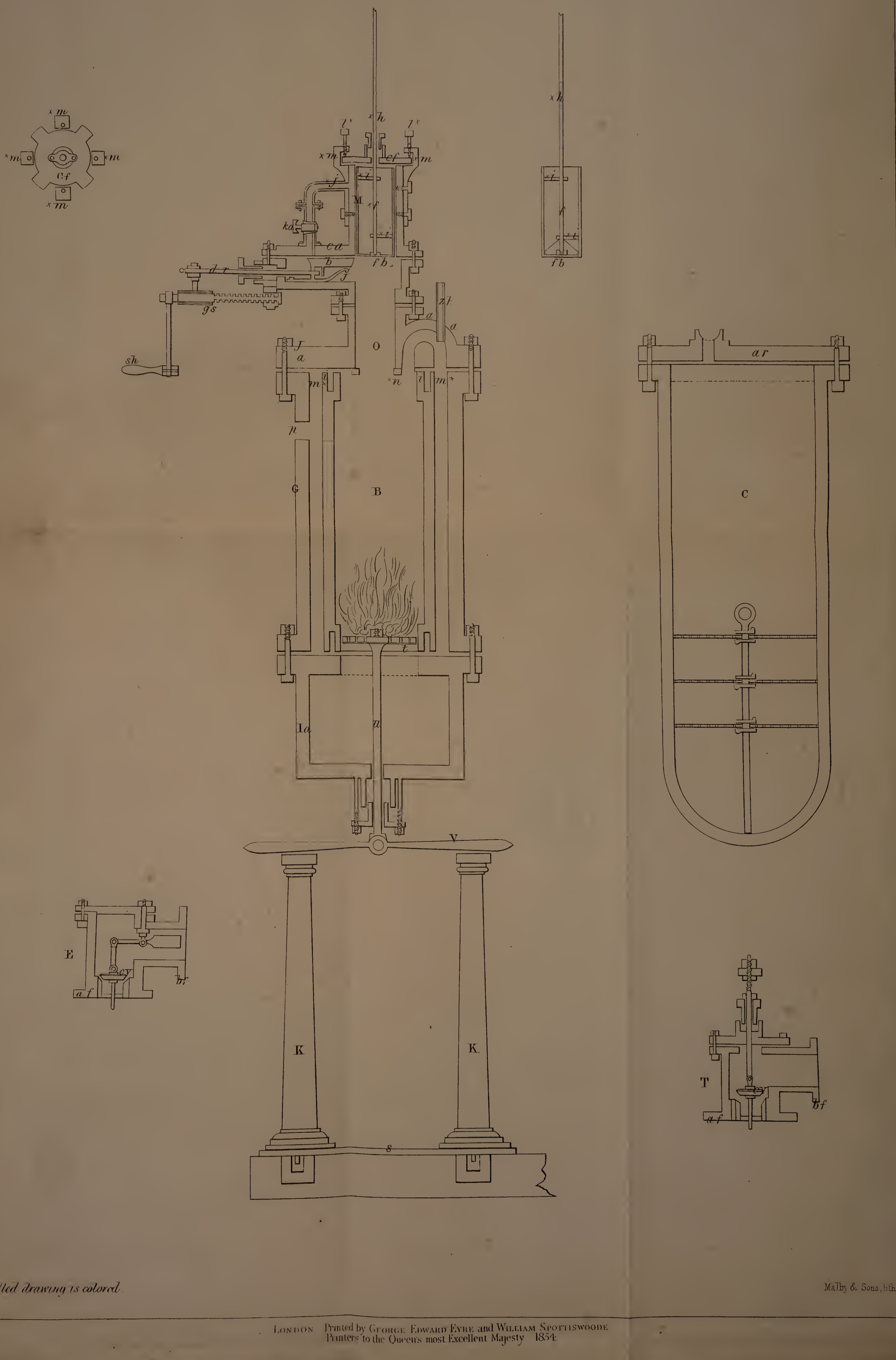
HALL'S SPECIFICATION.

(5. SHEETS.)

FIG. 4.

Elevation in Section of the Generetor & Reservoir &c.
Scale one inch to the foot.



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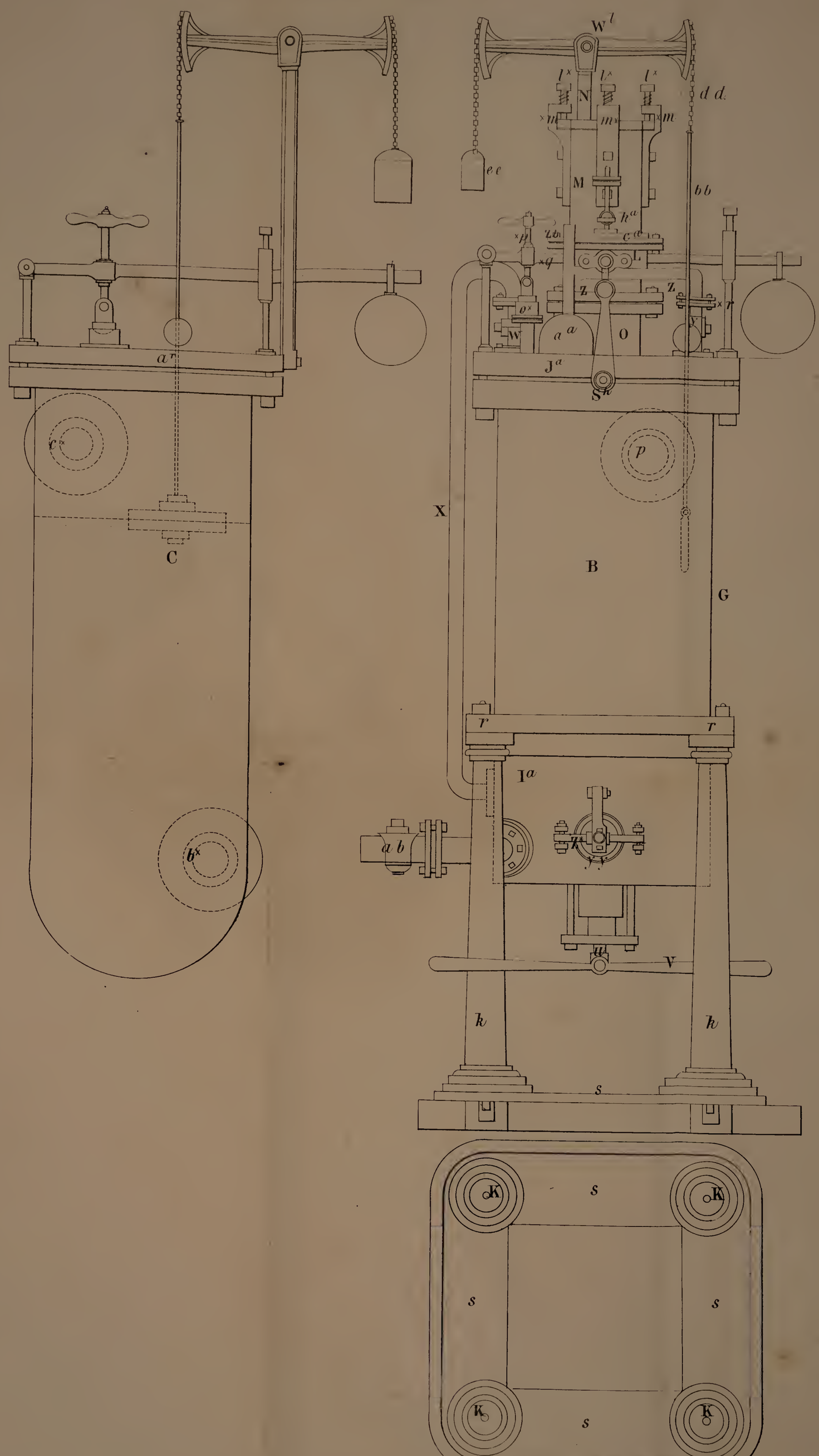
Elevation of the back of the Generator and Reservoir

Scale, one inch to the foot

FIG. 5.



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as well as other parts of the apparatus, by proper non-conducting substances. I wrap bands round them made of hay which answers very well. Although I have delineated the pistons in the atmospheric and working cylinders, I have to observe that any kind of piston suited for high pressure steam engines will be proper for my Invention.

Having now described my method and apparatus, I proceed to state that I do not claim the exclusive use of the cylinders, pistons, beam, valves, cocks, or other parts of the apparatus separately; but I claim as my Invention the method herein-before described, of generating steam and various gasses for the purposes aforesaid, by causing combustion of fuel to take place in an artificial atmosphere, such as has been mentioned in the manner and by the method above described. And also I claim the combination of apparatus herein-before described as a whole, for the purpose of generating steam and various gasses for the purposes aforesaid, by producing, maintaining, and beneficially applying the aforesaid artificial atmosphere, as herein-before described.

In witness whereof, I, the said Samuel Hall, have hereunto set my hand and seal, the Twenty-ninth day of November, in the year of our Lord One thousand eight hundred and twenty-eight.

SAMUEL HALL. (L.S.)

AND BE IT REMEMBERED, that on the same Twenty-ninth day of November, in the year above mentioned, the aforesaid Samuel Hall came before our Lord the King in His Chancery, and acknowledged the Specification aforesaid, and all and everything therein contained, in form aforesaid acknowledged. And also the Specification aforesaid was stamped according to the tenor of the Statute in that case made and provided.

Inrolled the same Twenty-ninth day of November, in the year above written.

SAM C. COX.

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